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Evaluating the Potential for Reverse Innovation in BRIC-T Countries: A Panel Data Analysis

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Abstract

A reverse innovation or trickle-up innovation is a term referring to an innovation which is likely to be adopted first in the developing world. Reverse innovation is required to be decentralized and focus to local-market. Innovation still originated with home-country needs, but products and services were later modified to win in each market. To meet the budgets of customers in poor countries, they sometimes de-featured existing products. From this point of view, multinationals complete the reverse innovation process by taking the innovations originally chartered for poor countries, adapting them, and scaling them up for worldwide use. In this study, we investigate the impact of reverse innovation on human development. To do this, we used the one-way fixed effect panel data technique. We concluded that increases in the number of researcher, the number of article and research and development expenditure % of GDP have a significantly positively impact on the BRIC-T countries' the Human Development Index. When analyzing the effects of resident patent applications and nonresident patent applications on education for the selected countries, we found that resident patent applications negatively affect education but nonresident patent applications positively affect it.

JEL classification numbers: C33, O30, I20
Keywords: Panel data analysis, Reverse innovation, Trickle-up innovation, Education, BRIC and Turkey

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1 Introduction

The concept of reverse innovation was first expressed by Immelt et al. in October 2009 in the study “How GE is disrupting itself”. Innovations are typically introduced in developed economies and then they are seen in the developing world. On the contrary, A reverse innovation is regarded as any innovation that is adopted first in the developing world. Reverse innovations reach developed world following its introduction in the developing ones. Several studies in the literature also define them as Gandhian or Frugal innovations [1,2] In other words, it is a known fact that multinational companies continue their research and development initiatives in the developed world and sell their newly invented products in poor countries. Reverse innovation is doing exactly the opposite. Reverse innovation is about innovating in poor countries and selling those products in rich countries. The issue of reverse innovation comes fore among others since two-thirds of world’s growth in gross domestic product (GDP) comes from poor countries [3].

Glocalization, the localization of global designs has sustained the expected results in the past 30 years. This strategy will not last forever due to the change of the path that the economic growth pursues. Because the epicenter of the global growth seems to be moving from the developed economies to the emerging ones, reverse innovation could be counted as the key factor in the next wave of global growth and product portfolio management [4].

The rise of emerging economies and globalization changed the location of innovative activities to some extent. China and India two leading countries contribute to innovative activities. These countries with their insufficient resources no longer adopt innovations of developed countries origin but they also provide innovations themselves from time to time [5].

Developing countries also known as the BRIC consists of Brazil, Russia, India and China. This concept was first introduced by Jim O’Neill for the first time in his article titled as “Building Better Global Economic BRICs” [6]. In his article O’Neil stressed the importance of these economies and the role that they could play in the 21st century. However, following years witnessed downturns in the economies of mentioned economies except for the China and therefore the author proposed the MINT countries (Mexico, Indonesia, Nigeria and Turkey) as an alternative to the BRIC economies [7].

The concept of BRIC has recently been used to signify the economic power that changes its course from G7 countries to developing countries (The Symbol of Changing Balance: BRIC”, Access Date: 20.11.2014). As stated in the National Innovation Index Report 2013 published by CASTED (Chinese Academy of Science and Technology for Development) China has demonstrated a straight upwards direction in its innovative activities in the index. China ranked 19 among other countries. The number of total countries that are listed in the index is 40 [8]:

1- Innovative capacity of the country is the highest among BRIC countries.
2- Knowledge creation ability of China is very high.
3- An approach based on innovativeness and sustainability have been adopted by Chinese Businesses.
4- China’s innovative capacity is still limited compared to developed countries.

BRIC countries can not be ignored when the figures they constitute are taken into consideration. These countries encompass 42 percent of the world’s population and 1/3 of the land. Their GDP and economic growth levels record high grades in the past years [9]. China became the second largest economy behind US in dollar PPP terms and surpassed

Japan in this field. However other BRIC countries, Brazil, Russian Federation and India were behind the developed economies of Japan, Germany France and United Kingdom. When the table is observed it can be said the next study will be about MINT countries.

Table 1: Country Rankings from Gross Domestic Product (GDP) 2013

Ranking	**Economy**	**Millions of US Dollars**
1	United States	16.768.100
2	**China**	**9.240.270**
3	Japan	4.919.563
4	Germany	3.730.261
5	France	2.806.428
6	United Kingdom	2.678.455
7	**Brazil**	**2.245.673**
8	Italy	2.149.485
9	**Russian Federation**	**2.096.777**
10	**India**	**1.876.797**
11	Canada	1.826.769
12	Australia	1.560.372
13	Spain	1.393.040
14	Korea, Rep.	1.304.554
15	Mexico	1.260.915
16	Indenosia	868.346
17	Netherlands	853.539
18	**Turkey**	**822.135**
19	Saudi Arabia	748.450
20	Switzerland	685.434

Source: World Development Indicators database, World Bank [19], 16 December 2014

Table 1 shows the country rankings based on GDP in 2013. The United States is the first country on the list with its 16 billion 768 million USD GDP. Following the USA, China is the second country with its 9 billion 240 million USD. Japan, Germany, France and UK are the followers of China. Brazil as another BRIC country recorded the amount of 2 billion 096 million USD. Following Brazil Italy is the 8th country and then Russian Federation and India constitute the 9th and 10th countries on the list. Turkey is at the 18th place on the list.

Turkey is among 20 largest economies in the world and it ranks number 18th on the list. If the country sustains its economic growth levels it will be using 2.3% of the planet's resources in 2050. In addition, forecasts suggest that E7 countries (Turkey, China, Indonesia, India, Russia, Mexico and Brazil) will probably surpass G7 economies (the USA, Germany Japan, Italy, France, Canada and the UK) with respect to their economic growth by 2032 [10].

2 Data, Model and Estimation Procedure

2.1 Data and Model

In this study, we investigate the impact of reverse innovation on human development. For this purpose, the equation (1) and the equation (2) are estimated through the one -way fixed effects estimator.

$$\log hdi_{it-1} = \alpha_i + \beta_1.\log patent\_ratio_{it} + \beta_2.\log researcher_{it-1} + \beta_3.\log rd_{it-1} + \beta_4.\log article_{it-1} + u_{it} \quad (1)$$

$$\log hdi_{it-1} = \chi_i + \delta_1.\log nonpatent\_ratio_{it} + \delta_2.\log researcher_{it-1} + \delta_3.\log rd_{it-1} + \delta_4.\log article_{it-1} + e_{it} \quad (2)$$

We used the human development index, as a proxy variable of education (hdi). The Human Development Index (HDI) is a summary measure of average achievement in key dimensions of human development: a long and healthy life, education, being knowledgeable and have a decent standard of living. The HDI is the geometric mean of normalized indices for each of the three dimensions. In addition, we used the share of resident patent applications in total patent applications (patent_ratio), the share of nonresidents patent applications in total patent applications (nonpatent_ratio), the number of researchers in Research and Development (researchers), the number of article in Scientific and technical journals (article) and research-development expenditure % of GDP (rd) as independent variables in this study. All variables are specified in logarithmic form and in their first-order differenced in order to obtain stationary variables. Data are gathered on yearly basis from 2001 to 2012 of BRIC-T countries[3]. All data are taken from World Bank. Also in order to carry out the paper E views 8.0 is used.
Table 1 shows some descriptive statistics for the data set. As a result, there is no sampling bias in the data. The means of all variables used for the empirical analysis are close neither to their minimum nor maximum value, which indicates that there is no disproportion. Moreover, the standard deviations of the variables are widely dispersed around the mean.

Table 2: Descriptive Statistics of Selected Variables

	rd	**article**	**researcher**	**total patent**	**nonpatent**	**patent**	**hdi**
Mean	0.985755	19087.56	1071.733	59003.89	23605.03	35398.85	0.664431
Median	0.984720	13500.40	621.6779	28649.00	13778.00	4721.000	0.686000
Maximum (country)	1.836170 (China)	89894.40 (China)	3460.198 (Russia)	526412.0 (China)	110583.0 (China)	415829.0 (China)	0.777000 (Russia)
Minimum (country)	0.479090 (Turkey)	3484.100 (Turkey)	111.2350 (India)	837.0000 (Turkey)	160.0000 (Turkey)	277.0000 (Turkey)	0.483000 (India)
Std. Dev.	0.301638	18530.70	1123.181	100602.5	28192.94	75175.36	0.084269

In order to estimate the equation (1) and the equation (2), we used the one-way fixed effect panel data technique. According to Baltagi [11], panel data technique that is used in empirical section of the study has some the advantages. These advantages can be summarized as: i) Panel data are able to control the heterogeneity that occurs among

[3]The countries consist of Brazil, Russian Federation, India, China and Turkey.

individuals, firms, states or countries whereas time-series and cross-section studies do not control the heterogeneity for these units. ii) Panel data give more informative data, more variability, less co-linearity among the variables, more degrees of freedom and so, more efficiency. iii) Panel data are relatively more suitable about the dynamics of adjustment than other techniques. iiii) Panel data model is better able to study more complicated behavioral models that pure time-series or pure cross-section models cannot study [12].

2.2 Estimation Procedure

2.2.1 Panel Unit Root Tests

Firstly, we test the stationarity of the selected series included in the regression model in order to obtain unbiased estimations. In this sense, we use the panel-based unit root tests of Levin, Lin and Chu [13] and Im, Pesaran and Shin [14].
A first generation of models has analyzed the properties of panel-based unit root tests under the assumption that the data is independent and identically distributed (i.i.d) across individuals.
In general, this type of panel unit root tests is based on the following regression:

$$\Delta Y_{i,t} = \beta_i . Y_{i,t-1} + Z_{i,t} . \gamma + u_{i,t} \tag{3}$$

where i = 1,2,…,N is individual, for each individual; T=1,2,…,T time series observations are available, $Z_{i,t}$ is deterministic component and $u_{i,t}$ is error term. The null hypothesis of this type is ρ_i=0 for $\forall_i$. The first of first generation panel unit root tests is LLC that allow for heterogeneity of individual deterministic effects and heterogeneous serial correlation structure of the error terms assuming homogeneous first order autoregressive parameters. They assume that both N and T tend to infinity but T increase at a faster rate, so N/T$\rightarrow$0. They assume that each individual time series contains a unit root against the alternative hypothesis that each time series stationary. Thus, referring to the model (3), LLC assume homogeneous autoregressive coefficients between individual, i.e. $\beta_i = \beta$ for all I, and test the null hypothesis $H_0 : \beta_i = \beta = 0$ against the alternative $H_A : \beta_i = \beta \prec 0$ for all i. The structure of the LLC analysis may be specified as follows:

$$\Delta Y_{i,t} = \alpha_i + \beta_i . Y_{i,t-1} + \delta_i . \tau + \sum_{j=1}^{p_j} \phi_{ij} . \Delta Y_{i,t-j} + u_{it} \tag{4}$$

where i = 1,…, N t= 1,…,T τ is trend, α_i is individual effects, u_{it} is assumed to be independently distributed across individuals. LLC estimate to this regression using pooled OLS. In this regression deterministic components are an important source of heterogeneity since the coefficient of the lagged dependent variable is restricted to be homogeneous across all units in the panel [15]. Other test, IPS test allows for residual serial correlation and heterogeneity of the dynamics and error variances across units. Hypothesis of IPS may be specified as follows [12]:

$H_0 : \beta_i = 0 \qquad H_A : \beta_i \prec 0$ for all i

The alternative hypothesis allows that for some (but not all) of individuals series to have unit roots. IPS compute separate unit root tests for the N cross-section units. IPS define their t-bar statistics as a simple average of the individual ADF statistics, t_i, for the null as:

$$\overline{t} = \sum_{i=1}^{N} t_i / N$$

It is assumed that t_i are i.i.d and have finite mean and variance and E(t_i), Var(t_i) is computed using Monte-Carlo simulation technique.

2.2.2 Estimation

2.2.2.1 The-One Way Fixed Effects Model

According to Hsiao [16], a longitudinal, or panel, data analysis provides multiple observation on each individual in the sample. Panel data sets for economic research have numerous advantages over cross-sectional or time-series data sets. Firstly, panel data give the researcher a large number of data points, increasing the degrees of freedom and reducing the collinearity among independent variables. So, panel data improve the efficiency of econometric estimates achieved. Secondly, panel data allow us to construct and analyze more complicated behavioral models than conventional cross-sectional or time series data. Besides these advantages, panel data provide the possibility of generating more accurate predictions for individual outcomes than time-series data alone [16].

Panel data may have group effects, time effects, or both. These effects are either fixed effect or random effect. A fixed effect model assumes differences in intercepts across groups or time periods. Fixed effects model explore the relationship between the predictor and outcome variables within an entity. This entity may be households, countries, firms. The model assumes all other time invariant variables across entities that can influence the predictor variables to be constant [17].

$$u_{it} = \mu_i + \lambda_t + v_{it} \qquad i = 1,\dots,N \qquad t = 1,\dots,T$$

where μ_i denotes the unobservable individual effect, λ_t denotes the unobservable time effect, and v_{it} is the stochastic disturbance term. λ_t is individual-invariant and it accounts for any time-specific effect that is not included in the regression [11].

Fixed effects model can be formulated as [12]:

$$y_{it} = x'_{it}.\beta + \alpha_i + \varepsilon_{it} \qquad (5)$$

where α_i denotes all the observable effects and it is group-specific constant term in the regression model. α_i equals $z'_i.\alpha$ in the regression (5). If z_i is unobserved, but correlated with x_{it}, then the coefficient of β is biased and inconsistent under assumptions of $E(u_{it}) = 0$; $E(u^2_{it}) = \sigma^2$ all i; $E(u_{it}.u_{jt-s}) = 0$ for $s \neq 0$ and $i \neq j$

3 Empirical Results

Table 2 presents the results of the panel unit root tests. According to Table 2, the results of the panel unit root tests confirm that other data series, except for the variables of nonpatent_ratio, are non-stationary at level while these series are stationary after taking their first-differences.

Table 3: Panel Unit Root Test for the period 2001-2012

	Constant			
	IPS		**LLC**	
Variable	**Stat.**	**p-value**	**Stat.**	**p-value**
hdi	3.01510	0.9987	0.44655	0.6724
rd	0.75869	0.5828	0.20911	0.5828
researcher	-1.28001	0.1003	-2.70816***	0.0034
article	2.52940	0.9943	2.72024	0.9967
patent_ratio	0.89910	0.8157	-0.41138	0.3404
nonpatent_ratio	-10.7572***	0.0000	-10.5800***	0.0000
dhdi	-5.61882***	0.0000	-8.36540***	0.0000
drd	-3.00683***	0.0013	-4.11728***	0.0000
dresearcher	-3.53865***	0.0002	-4.95492***	0.0000
darticle	-2.20228**	0.0138	-4.88314***	0.0000
dpatent_ratio	-2.95439***	0.0016	-5.01784***	0.0000

d is the first difference operator. L is the logarithm of the variable. ***,** denote the rejection of the null at the 1% and 5% levels respectively.

We use a specific country group (BRIC-T countries) in the study so fixed effect panel data analysis is useful [18]. The results from the one-way fixed effects for the equation (1) and the equation (2) are shown in Table 3 and Table 4, respectively.

Table 4: The Results for One-way Fixed Effects for the Equation 1

Dependent Variable: dhdi

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-1.393804	0.083555	-16.68126	0.0000
dpatent_ratio	-0.022311	0.003567	-6.255576***	0.0000
dresearcher	0.040070	0.011474	3.492213***	0.0010
drd	0.123860	0.018428	6.721091***	0.0000
darticle	0.072508	0.009158	7.917638***	0.0000

d is the first difference operator. It was taken natural log of data of all variables. *** and** indicate the statistical significance at 1% and 5% levels respectively.

Table 5: The Results for One-way Fixed Effects for the Equation 2

Dependent Variable: dhdi

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-1.204806	0.096588	-12.47362	0.0000
dnonpatent_ratio	0.014544	0.004557	3.191796***	0.0024
dresearcher	0.031642	0.015431	2.050527**	0.0455
drd	0.156238	0.018915	8.260141***	0.0000
darticle	0.062315	0.012802	4.867592***	0.0000

d is the first difference operator. It was taken natural log of data of all variables. *** and** indicate the statistical significance at 1% and 5% levels respectively.

From Table 3 and Table 4, we can see that increases in the number of researcher, the number of article and research and development expenditure % of GDP have a significantly positively impact on the BRIC-T countries' the Human Development Index, used as a proxy variable of education. When analyzing the effects of resident patent applications and nonresident patent applications on education for the selected countries, we found that resident patent applications negatively affect education but nonresident patent applications positively affect it. Thus, we can say that nonresident patent applications, the number of researcher, the number of technical and scientific article, research-development expenditure % of GDP, which are used as innovation performance measurements provide a positive contribution in reaching higher levels of education for BRIC-T countries.

References

[1] V. Sehgal, K. Dehoff and G. Panneer (2010) "The Importance of Frugal Engineering. Economic Times Mumbai", Issue 59, 2010. In G. M. Ivan, D, H. Alfonso and G. C. Esmeralda, "Application of Reverse Innovation in SMEs", Book of Proceedings of the 7th International Conference on Industrial Engineering and Industrial Management, XVII Congreso de Ingenieria de Organizacion, pp.180-181.

[2] Prahalad C.K., Mashelkar R.A. (2010) "Innovation's Holy Grail", Harvard Business Review July-August 2010 132-141. In G. M. Ivan, D, H. Alfonso and G. C. Esmeralda, "Application of Reverse Innovation in SMEs", Book of Proceedings of the 7th International Conference on Industrial Engineering and Industrial Management, XVII Congreso de Ingenieria de Organizacion, pp.180-181.

[3] V. Govindarajan, "Reverse Innovation Starts with Education", https://hbr.org, November 18, 2013, Erişim Tarihi 26.11.2014.

[4] N. Gautam. "Reverse Innovation – Enablers & Opportunities", www.autotechreview.com, January 2013, Volume 2, Issue 1, pp. 54.

[5] V. Govindarajan and R. Ramamurti. "Reverse Innovation, Emerging Markets, and Global Strategy", Global Strategy Journal, 1: 191-205, 2011, pp. 191.

[6] J. O'Neill, "Building Better Global Economic BRICs", Global Economics Paper No:66, November 2001.

[7] J. Martinez, "Emerging Nations", www.socsci.uci.edu, Erişim Tarihi: 20.11.2014.

[8] Z. Ning, "China Science and Technology Newsletter", Department of International Cooperation Ministry of Science and Technology (MOST), P.R. China, No.11, June 10, 2014, pp.1-3.

[9] P. Wennström, R. Gupte and I. Secches, "BRIC Market Innovation Strategies", AgroFOOD Industry Hi-Tech. May/June 2011, vol. 22, no. 3, pp. 8.

[10] TUSIAD, "Vision 2050 Turkey Report", http://www.tusiad.org.tr/information-center, erişim tarihi 01.02.2015).

[11] B. Baltagi, "Econometric Analysis of Panel Data", Third Edition, Chichester: John Wiley & Sons, Ltd., 2005.

[12] M. Ener, C. Kılıç and F. Arıca. "The Effect of Total Petroleum Consumption on Current Account Balance: An Application for Upper-Middle Countries", International Journal of Economy, Management and Social Sciences, 2(12) December 2013, pp. 996-1001.

[13] A. Levin, C. Lin, and J. C. Chu. (2002), "Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties," Journal of Econometrics 108, pp 1-24.

[14] K.S. Im, M. H. Pesaran and Y. Shin. "Testing for Unit Roots in Heterogeneous Panels", Journal of Econometrics, 2003, 115, 53-74.

[15] L. Barbieri. “Panel Unit Root Tests: A Review”, Quaderni del Dipartimento di Scienze Economiche e Sociali. Serie Rossa, n.43, Università Cattolica del Sacro Cuore, Piacenza, 2006.
[16] C. Hsiao. “Analysis Of Panel Data”, Cambridge: Cambridge University Pres, 2003.
[17] O. Torres-Reyna. “Panel Data Analysis: Fixed and Random Effects”, http://dss.princeton.edu/training/Panel101.pdf, 2007.
[18] B. H. Baltagi. “Econometric Analysis of Panel Data”, 4th Ed., John Wiley & Sons, Ltd., 2008.